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DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF FISHERIES

GEORGE M. HOWARD, Commissioner

THE SEAWEED INDUSTRIES OF JAPAN
THE UTILIZATION OF SEAWEEDS IN THE
UNITED STATES

BY

HUGH M. SMITH

Deputy U. S. Fish Commissioner

Extracted from BULLETIN OF THE BUREAU OF FISHERIES No. 1004, Vol. XLIV. Pages 166 to 191
Plates I to V



WASHINGTON
GOVERNMENT PRINTING OFFICE
1905



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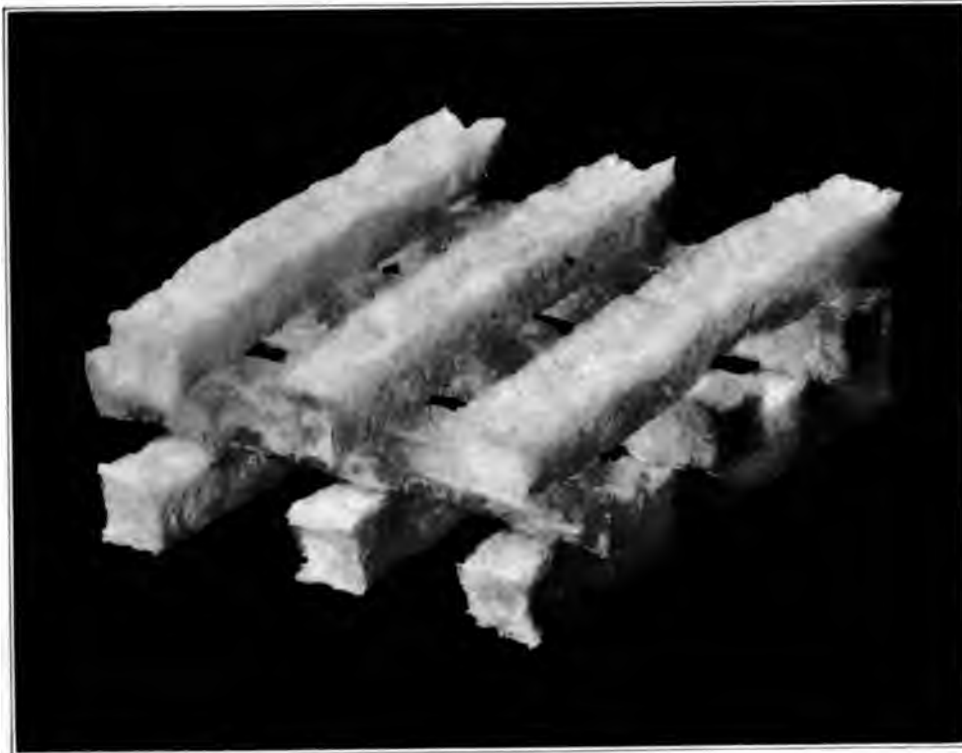
Extracted from BULLETIN OF THE BUREAU OF FISHERIES for 1904, Vol. XXIV. Pages 133 to 181
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THE SEAWEED INDUSTRIES OF JAPAN.

By HUGH M. SMITH,
Deputy U. S. Fish Commissioner.



BAR OR "SQUARE" KANTEN.



A BUNDLE OF "SLENDER" KANTEN.
KANTEN, OR SEAWEED ISINGLASS.

THE SEAWEED INDUSTRIES OF JAPAN.

By HUGH M. SMITH,
Deputy U. S. Fish Commissioner.

Seaweeds are among the most valuable of the aquatic resources of the Japanese Empire, and conduce largely to the prominent rank attained by the fisheries of that country. While marine plants are extensively utilized in France, Ireland, Scotland, and other European countries, in the East Indies, in China, and elsewhere, in no other country are such products relatively and actually so important or utilized in such a large variety of ways as in Japan.

The seaweed industries of Japan owe their importance to the great extent of the coast line (estimated at 18,000 miles); to the abundance and variety of useful algæ; and to the ingenuity of the people in putting the different kinds of plants to the most appropriate uses and in utilizing them to the fullest extent.

The value of the seaweeds prepared in Japan at the present time exceeds \$2,000,000 annually, this sum excluding the value of very large quantities of marine plants which do not enter into commerce but are used locally in the families of the fishermen.

In view of the extent and long continuance of these industries, some diminution in the supply of economic algæ might reasonably be looked for, and this has in fact occurred; but while excessive gathering has influenced the abundance of some species, much more serious decrease has been brought about by conditions not connected with the seaweed industries. Investigations conducted by the imperial fisheries bureau have indicated that the disappearance of useful algæ on a number of sections of the coast has resulted from a temporary freshening of the littoral waters, probably owing to improper lumber operations near the headwaters of streams. The denuded areas have always been contiguous to the mouths of rivers or within the possible range of influence of streams during freshets. It is reported that in a few places certain algæ have been able partly to reestablish themselves, but the process is very slow, and complete replenishment will require many years, even if no lowering of water density ensues in the meantime. Some experimental planting in the denuded districts has been undertaken with favorable results, but on a very small scale. In other parts of Japan cultivation is extensively carried on, but as yet is directed to practically only one species, the laver (*Porphyra laciniata*).

It is noteworthy that the disappearance of seaweeds has injuriously affected another fishery—namely, that for abalones, which rank among the important water products of Japan. These mollusks feed among the algæ and are no longer found on large areas of bottom on which they formerly abounded.

The general name applied to algæ in Japan is nori, which is also often given to the prepared products. The term enters into numerous combinations, as will be seen in the following chapters. The seaweed preparations to which special attention is given are kombu, amanori, funori, kanten, and iodine. All of these can be made in the United States, and it is largely with a view to pointing out the possibilities for a successful business in some or all of these products that this report is submitted.

The information herewith presented embodies a brief account of the methods of taking and utilizing seaweeds in Japan, and is based on personal inquiries by the writer in 1903. Statistical and other useful data have been furnished by Dr. K. Kishinouye and Dr. K. Oku, of the imperial fisheries bureau, Tokyo. To Doctor Oku, especially, the writer is under great obligations for assistance and information, without which the preparation of this paper would have been impracticable. A number of manufacturers of seaweed products supplied samples, gave information, and accorded facilities for inspecting their establishments; among those to whom special acknowledgments are due are Messrs. Risuke Yamamoto, Hikobei Nakanisi, Hikobei Matsushita, Kingo Matsushita, and Manjiro Nakajima, all of Osaka.

The biological and commercial aspects of the Japanese seaweeds have been considered in various official reports, the most complete of which are published only in the Japanese language and are not available for foreign readers. The following publications have been consulted in the preparation of this paper, and some of the illustrations herein shown have been copied or adapted therefrom. Only the first three papers are in English.

JAPANESE BUREAU OF AGRICULTURE.

- 1893. Useful Algæ, in Descriptive Catalogue of Exhibits relating to the Fisheries of Japan at the World's Columbian Exposition. Tokyo, 40 pages.
- 1894. Utilization of Algæ, in The Fisheries of Japan. Compiled and arranged from the foregoing catalogue by Hugh M. Smith. Bulletin U. S. Fish Commission, 1893, pp. 419-438.

K. YENDO.

- 1902. Uses of Marine Algæ in Japan. Postelsia, The Year Book of the Minnesota Seaside Station, 1901, pp. 1-18. St. Paul, 1902.
- 1903. Investigations on Isoyake (decrease of seaweed). Journal of the Imperial Fisheries Bureau, Vol. XII, No. 1, 1903.

MIYABÉ, YAMAGAWA, AND OSHIMA.

- 1902. On the Laminariaceæ and Laminaria Industries of Hokkaido, being Part III of Report on Investigations of the Marine Resources of Hokkaido, pp. 212, numerous plates. Sapporo, 1902.
 - I. On the Laminariaceæ of Hokkaido. By Prof. Kingo Miyabé.
 - II. On the Laminaria Industries of Hokkaido. By Shin Yamagawa.
 - III. Chemical Analysis of Laminaria. By Prof. Kintaro Oshima.

T. NISHIMURA.

- 1903. Manufacture of Funori (seaweed glue) in the Prefectures of Tokyo, Osaka, and Miyé. Journal of the Imperial Fisheries Bureau, Vol. XII, No. 3, 1903.

K. OKU.

- 1904. Preparation of Kizami-kombu (green-dyed laminaria) in the Prefecture of Osaka. Journal of the Imperial Fisheries Bureau, Vol. XIII, No. 2, 1904.

KANTEN, OR SEAWEED ISINGLASS.

NATURE AND IMPORTANCE OF KANTEN.

A very valuable and interesting product of seaweeds, comparable to isinglass and used for some of the same purposes, is known to the Japanese as *kanten*. This name is like so many of the fanciful terms with which the Japanese invest common objects; it means "cold weather," and has reference to the circumstance that this article is and can be made only during the colder months (December to February).

In 1903 there were in Japan 500 establishments for the manufacture of *kanten*, located in Osaka, Kyoto, Hyogo, Nagamo, and elsewhere. The average capacity of the factories is 3,000 kin, or about 4,000 pounds. The leading manufacturer has his warehouses and store in Osaka, and his factory at Hyogo, where 70 to 80 persons are employed. Mountainous regions are the best for this industry, because of the dryness and purity of the air.

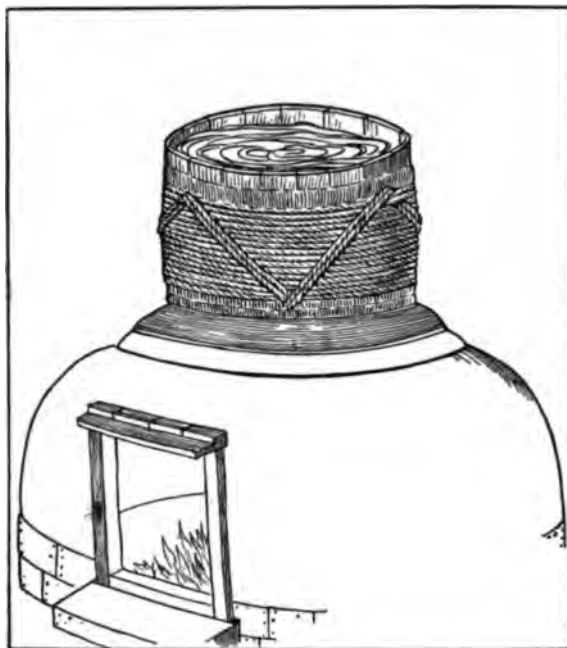
Kanten has been made since about 1760. In the early years it was simply a



"Tengusa" (*Gelidium corneum*).

mass of jelly formed by the boiling of the seaweed, but at the present time the entire output is in the more convenient form of sticks and bars, a manner of preparation which was taken up quite accidentally; some soft jelly was thrown out of doors and congealed in the shape of slender sticks, suggesting the idea of preparing it in this form. *Kanten* is made from algæ of the genus *Gelidium*, the principal species being *G. corneum*. The Japanese name for the plant is *tengusa*, a contraction of *kantengusa*, meaning "weed for *kanten*." Several similar seaweeds are used as substitutes or adulterants, but are not so good as *Gelidium*. The algæ grow on rocks, and are taken by diving, the gathering season being May to October, though July and August are the best months. The principal supply comes from Hokkaido and the prefectures of Shizuoka, Miye, and Wakayama. The weed is dried on the shores, some bleaching taking place at the time of drying, and is then ready for sale to the manufacturers.

In 1903, the dried weed was selling in Osaka at 6 to 9 cents per pound; the substitute algæ brought 4 to 6 cents. The total crop of dried kanten algæ in 1900 was valued at \$113,140; the fishermen's sales in 1901 were \$125,282.



Furnace and tub for the boiling of *Gelidium*.



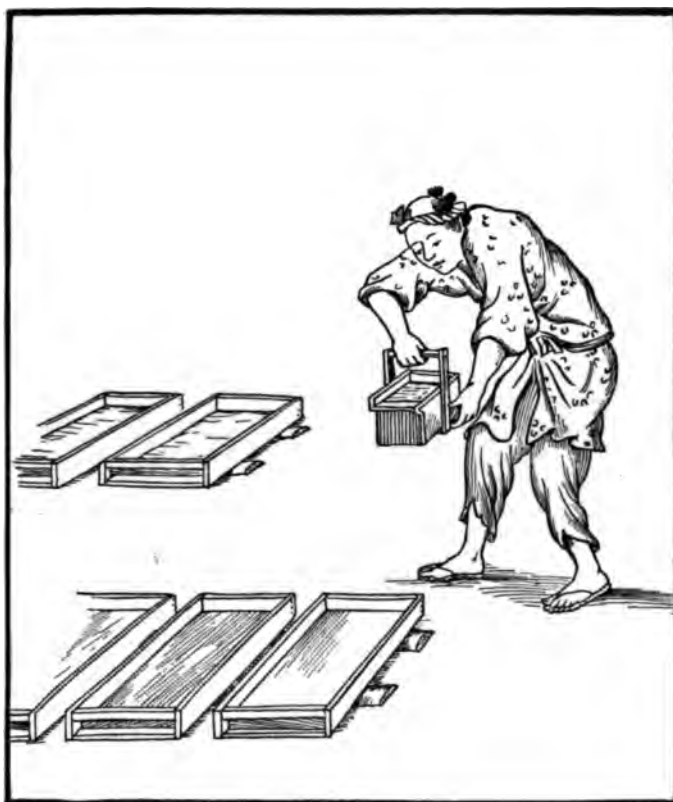
Press for straining crude sea-weed jelly.

THE PREPARATION OF KANTEN.

The process of making kanten is quite elaborate, although the appliances required are simple and inexpensive.

(1) The first step is the removal of all foreign matter from the masses of dried algæ. Calcareous and other hard particles are dislodged by beating and pounding, and other substances are picked out by hand. Further cleaning is effected by washing in running fresh water.

(2) The wet algæ are then spread in thin layers on flakes with bamboo or reed tops, through which the water drains. The principal object in thus spreading the algæ is to bleach them; this is done in warm weather, beginning in August, and is facilitated by dew. Under favorable conditions, twenty-four hours may be sufficient, but usually several days are required.



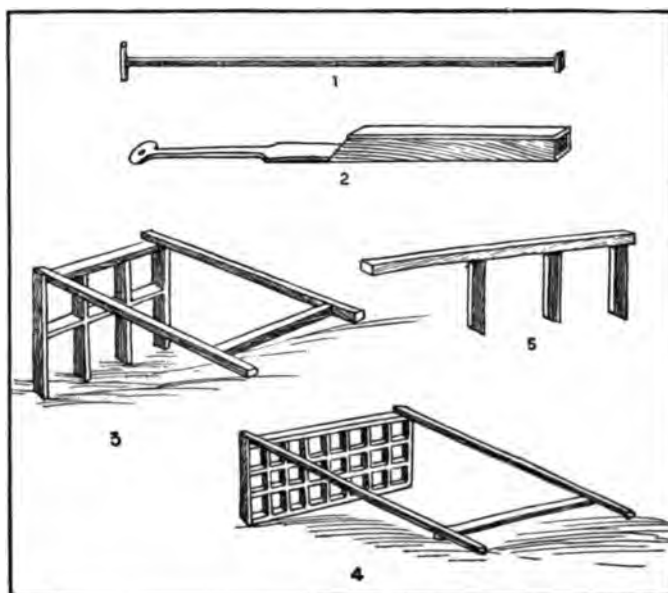
Pouring liquid kanten into cooling trays.

(3) As the drying goes on, the algæ become agglutinated and more or less fused, forming loose-meshed sheets. These sheets are loosely rolled and, as required, are boiled in fresh water in a large iron kettle or a wooden tub placed over a specially constructed oven or furnace. The boiling extracts the gelatin, and a thick, pulpy mass results. From the boiling kettle the jelly is strained or filtered through coarse cloths into a vat or tank, this preliminary straining being followed by a more thorough straining through linen bags of coarse mesh, which are placed in a crib and squeezed by means of a lever, the jelly falling into a large vat under the press.

(4) From the vat the jelly is dipped with a peculiar rectangular wooden vessel and poured into wooden trays to cool. These trays are about 2 feet long, 1 foot wide, and 3 inches deep, and are arranged in rows in the open air, resting on parallel poles so as to be clear of the ground.

(5) At a certain stage of the cooling and hardening process, the contents of the trays are cut into pieces of uniform size, in order to facilitate handling. The cutting is done by means of oblong iron frames, adapted to the shape of the trays, divided into squares of various sizes. One face of the frame has sharpened edges, and the cutting is done by inserting the frame along one side of the tray and drawing it horizontally through the jelly.

(6) The bars are then put one by one in a wooden box slightly larger than themselves and with a coarse wire grating over the lower end. A wooden piston with a broad end fits into this box, and is pushed against the bar of jelly, forcing it



Articles used in cutting sea-weed jelly into sticks and bars.

through the grating in the form of slender sticks. Another way in which kanten is prepared is in the form of blocks, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches square and 10 to 12 inches long, which are made with a cutting frame such as has been referred to. There is a shrinkage of one-third in bulk in the course of solidifying.

(7) The sticks and bars of hardening jelly are arranged in regular rows on flakes occupying an exposed position on a mountain or hillside. The congealing requires one to three days, according to wind and temperature, and a further drying of three or four days is usually allowed. A northwest wind is considered as giving the best results.

(8) The thoroughly dried pieces are trimmed to uniform lengths and baled for shipment. The thin sticks, known as *huoso-kanten* (slender kanten), are 10 to 14 inches

long and about one-eighth of an inch thick, and are tied into bundles weighing about 6 to 10 ounces; the bundles are packed in bales holding 100 kin (133 pounds), incased in several layers of matting. The blocks, which are called *kaku-kanten* (square kanten), are not adapted for close packing, and make a very bulky bale; about 50 blocks weigh 1 pound.

THE USES OF KANTEN.

Kanten is pearly white, shiny, and semitransparent, having in block form a loose, flaky structure, and is tasteless and odorless. In cold water it swells but does not dissolve, but in boiling water it is readily soluble and on cooling forms a jelly.

In Japan kanten is used largely for food in the form of jellies (often colored), and as adjuvants of soups, sauces, etc. It is also used for purifying saké, the native wine made from rice. In foreign countries kanten is employed in a variety of ways, although chiefly in food preparations where a gelatin is required, such as jellies, candies, pastries, and many desserts, in all of which it is superior to animal isinglass. It is also used for the sizing of textiles, the stiffening of the warp of silks, the clarifying of wines, beers, coffee, and other drinks, the making of molds required by workers in plaster of Paris, and sometimes in the manufacture of paper. In China one of its uses is as a substitute for edible bird nests. The large consignments of square kanten to Holland are doubtless destined for the schnapps factories. A very important use in all civilized countries is as a culture medium in bacteriological work; the product is known in the scientific world under the name *agar-agar*, which is the Ceylonese equivalent of kanten. For this purpose a very pure grade of slender kanten is required.

The following chemical analyses of kanten have been made by Dr. O. Kellner, formerly a professor in the Agricultural College of Tokyo University, and by the Imperial Fisheries Bureau, respectively:

Substances.	I.	II.
	<i>Per cent.</i>	<i>Per cent.</i>
Water	22.80	22.29
Protein	11.71	6.85
Fiber		6.73
Carbohydrates	62.06	60.32
Ash	3.44	3.81
Total	100.00	100.00

OUTPUT, EXPORTS, MARKETS, AND PRICES.

The quantity of kanten prepared in 1900 was 2,370,517 pounds, valued at 1,153,003 yen (or \$576,500); and in 1901, 2,177,867 pounds, valued at 1,068,463 yen (\$534,232). No later statistics of production are available, but judging from the exports of 1902, the output in that year was apparently larger than ever before, probably reaching 3,000,000 pounds, with a value of \$750,000. The exports for a term of years and some detailed statistics of production are shown in the accompanying tables:

Kanten produced in Hyogo, Kyoto, and Nagano in the years 1897-1901.

Town and year.	Quantity.	Value.	Town and year.	Quantity (square pieces).	Value.	Town and year.	Quantity (slender kanten).	Value.
Hyogo (Muko district):	Pounds.		Hyogo (Kawabe district):	Number.		Hyogo (Kawabe district):	Pounds.	
1897.....	265,834	\$60,115	1897.....	2,226,667	\$7,345	1897.....	7,659	\$1,436
1898.....	283,867	73,396	1898.....	2,213,334	7,331	1898.....	6,984	1,560
1899.....	294,667	85,965	1899.....	2,346,667	7,701	1899.....	12,200	2,451
1900.....	317,334	83,563	1900.....	2,466,667	9,300	1900.....	15,854	2,664
1901.....	312,000	68,450	1901.....	2,626,667	9,713	1901.....	16,800	7,305
Town and year.			Town and year.			Town and year.		
Quantity.			Quantity.			Quantity.		
Value.			Value.			Value.		
Kyoto:	Pounds.		Nagano:	Pounds.		Kyoto:	Pounds.	
1897.....	211,471	\$32,080	1897.....	275,012	\$90,770	1897.....	275,012	\$90,770
1898.....	171,951	36,444	1898.....	291,307	71,358	1898.....	291,307	71,358
1899.....	74,851	16,510	1899.....	276,891	67,249	1899.....	276,891	67,249
1900.....	204,615	68,865	1900.....	331,480	95,305	1900.....	331,480	95,305
1901.....	259,330	55,520	1901.....	356,305	124,106	1901.....	356,305	124,106

The importance of the kanten industry in Osaka is indicated by the following table, showing an output of over 1,190,000 pounds in 1901:

Statistics of kanten production in Osaka, 1897 to 1901, inclusive.

Year.	Slender kanten.	Square kanten.	Total.
	Kin. a	Kin.	Kin.
1897.....	765,000	160,125	925,125
1898.....	774,000	167,750	941,750
1899.....	810,000	172,500	982,500
1900.....	795,000	150,938	945,938
1901.....	758,800	134,550	893,350

a 1 kin=1.33 pounds.

The exports of kanten during the thirty-four years ending with 1902, as shown in the following table, were 37,196,466 kin (or 49,595,288 pounds), valued at 14,646,910 yen (or \$7,323,455). The exports in 1902 were larger than ever before, amounting to 1,655,501 kin (or 2,207,335 pounds), valued at 1,108,544 yen (or \$544,272). The average price per 100 kin increased from 29.80 yen (or \$14.90) in 1869 to 76.80 yen (or \$38.40) in 1901, and 66.60 yen (or \$33.30) in 1902.



SPREADING THE WET SEAWEED ON MATS TO BLEACH AND DRY.



VIEW IN THE YARD OF A FUNORI FACTORY IN OSAKA.

THE MANUFACTURE OF FUNORI, OR SEAWEED GLUE.

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SPRINKLING THE SHEETS TO PREVENT CURLING.



GATHERING THE DRIED SHEETS FOR BALING AND SHIPMENT.

THE MANUFACTURE OF FUNORI, OR SEAWEED GLUE.

THE RAW PRODUCTS.

The seaweeds used in the manufacture of kombu are coarse, broad-fronded members of the kelp family (Laminariaceæ), and are obtained almost entirely from Hokkaido, the most northern of the main islands of the Japanese archipelago. The kelps grow in abundance on all parts of that coast, but those of best quality—that is, with the widest and thickest fronds—are obtained from the northeastern coast, within the influence of the Arctic current. Those most used are of the numerically large genus *Laminaria*, and include the species *japonica*, *religiosa*, *angustata*, *longissima*, *ochotensis*, *yezoensis*, *fragilis*, *diabolica*, *gyrata*, and several others recently described by Professors Miyabé and Oshima. Other kelps which are utilized in kombu manufacture are *Arthrothamnus bifidus* and *kurilensis*, *Alaria fistulosa*, and various other species of *Alaria*.

*Arthrothamnus bifidus.**Alaria crassifolia.*

Kelps used in preparing kombu.

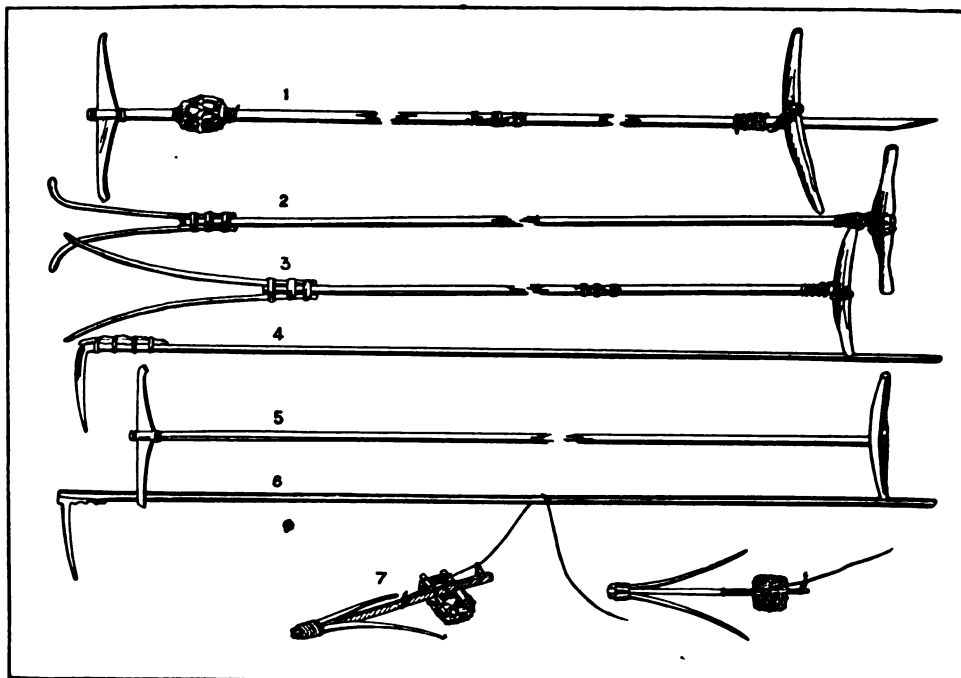
The gathering of kelp begins in July and ends in October, and is engaged in by many fishermen, among whom may be found some Ainus, the peculiar aboriginal inhabitants of Japan now confined to Hokkaido. The fishermen go to the kelp grounds in open boats, each boat with one to three men and a complement of hooks with which the kelp is torn or twisted from its strong attachment on the rocky bottom. The hooks are of various patterns; some are attached to long wooden handles, and some are weighted and dragged on the bottom by means of ropes while the boats are under way.

When the boats return to shore the kelp is carefully spread on the beaches in the vicinity of the villages and there left until thoroughly dried. The curing

accomplished, the plants are taken indoors and prepared for shipment. The stem is cut off, and at the same time the basal end of the frond is neatly trimmed. Plants of the same size and quality are tied together into long flat bundles of rather uniform size, and these bundles are sent by water to the kombu manufacturers.

KOMBU PREPARATIONS.

The forms in which kombu is made ready for consumption number a dozen or more, and illustrate the ingenuity of the Japanese in providing a varied regimen from a single article. Some of the preparations are not pleasing to the taste of



Forms of hooks used in gathering kelp in Hokkaido.

the average foreigner, but others are highly palatable and ought to prove very acceptable to Americans and Europeans.

Shredded or sliced (kizami) or green-dyed (ao) kombu.—This is one of the most important preparations of kombu, being largely consumed at home and also extensively exported. The steps in the manufacture are as follows:

(1) The dried kelp, as received in bundles from the Hokkaido fishermen, is immersed in large, covered, stationary iron kettles or vats containing a strong solution of a dye in fresh water. A wood fire is kept under the kettles, and the solution is maintained at a boiling temperature, the kelp being left therein for fifteen to twenty minutes and stirred from time to time. The dyeing imparts a uniform color to the prepared product as placed on the market, and thus serves the same purpose as the dyeing of canned French peas. Formerly a copper salt (carbonate or

sulphate) was employed, but the use of copper in this way has recently been prohibited by the government, and an aniline dye (malachite green) is now employed, although the latter is regarded with less favor by the manufacturers. The kelp is thoroughly cooked, and is saturated with the dye, which remains insoluble.

(2) The dyed fronds are drained and then taken into the open air, where they are either spread on straw mats or suspended on poles to dry. In order to economize space, a tier of horizontal poles covered with kelp may be placed between two upright poles, and in the yards of many of the kombu works the lines of freshly dyed kelp may be seen high in the air.

(3) When the drying has proceeded to a point where the surface of the kelp is



Kelp fishermen of Hokkaido.

no longer wet, the fronds, taken one at a time and carefully spread, are rolled into wheel-shaped masses about 1 foot in diameter, in order to facilitate subsequent handling. The rolls are tied by ropes to keep them in shape, and then go to women, who unroll the fronds one by one and arrange them flat in wooden frames, making a pile $1\frac{1}{2}$ feet high, 5 or 6 inches wide, and the full length of the fronds. Each pile is then tightly compressed by four transverse cords, and cut by means of a knife into four equal lengths, each held by a cord.

(4) The cut pieces are then arranged by hand in a rectangular frame 4 to 5 feet square, its thickness corresponding to the length of the sections of seaweed. When the frame is filled by the evenly arranged pieces, which are sprinkled with water in order that they may pack more closely, the whole mass is highly compressed by

means of ropes, wedges, and levers. One of the side boards forming the frame is then removed, the frame is supported at a convenient height and tilted at a convenient angle, and the kelp is reduced to shreds by means of a hand plane, which cuts the fronds lengthwise along their edge. A factory has from 5 to 10 cutters, each with a separate press, and each using his plane in what to us seems an awkward manner—that is, he cuts by drawing the plane toward himself rather than by pushing it from him. Formerly the cutting was done with a knife held in the hand. The substitution of a plane, by which shreds of more uniform thickness are obtained and the work done more expeditiously, is practically the only improvement in method in nearly two centuries.

(5) The shredded kelp is spread on mats or on board platforms in the open air,



Drying kelp on the beach in Hokkaido.

and repeatedly turned to secure uniform drying. When the surface has become dry, but the interior still retains its moisture as shown by the pliability of the shreds, the shavings are stored under cover and are ready for packing and shipment.

The completed product resembles in color, shape, and feel the "Spanish moss" which festoons the trees in the Southern States. For local use it is put in paper packages, for export to China in wooden boxes. If dry it will keep for a year or longer without deterioration.

Other kombu preparations.—Those species of kelp with the thickest and widest fronds are often dried with special care, so that they will lie flat and smooth, and are used in making kombu products for which the thin, narrow-fronded species are not well adapted. The different kinds of kombu now to be mentioned have been



WOMEN ENGAGED IN SORTING THE CRUDE KELP.



DYED KELP DRYING ON POLES; SHREDDED KOMBU DRYING ON MATS AND READY FOR BALING.

VIEWS AT AN OSAKA KOMBU FACTORY.



(g) The dried pieces just mentioned are sometimes pulverized and put through a fine wire sieve like a flour sieve, yielding a slightly greenish or grayish flour. A white and still finer powder is made from the deeper layers of the frond. The powdered preparations are named *saimatsu* (finely powdered) kombu. Such powders are sometimes compressed into small cakes of various shapes and coated with sugar.

(h) A form of kombu known as *cha* (tea) kombu is prepared by taking fronds which have been subjected to the first scraping process, reducing them to shreds in the usual way by planing and, after drying, cutting the shreds into half-inch lengths comparable to the rolled leaves of green tea.

FOOD QUALITIES OF KOMBU.

Kombu enters into the dietary of every Japanese family, and is one of the standard foods of the country, the various preparations having different flavors and being used for different purposes. The green-dyed and shredded kombu is cooked with meats, soups, etc., and is also served as a vegetable. Strips of the dried untreated fronds are cooked with soups, fish, and vegetables, for the purpose of imparting a flavor. Fronds after being scraped once are cut in $\frac{1}{4}$ -inch squares and boiled in soy-bean sauce, which treatment preserves them for a long time, and these pieces make an excellent relish, tasting like caviare or anchovy sauce. The Japanese name, *tsukudani*, means "boiled with soy-bean sauce." The tea kombu and the green and white powdered kombu are used as tea, boiling water being poured on a small quantity of the preparation and a palatable drink resulting. In Osaka the pulpy or pasty residue is eaten. The powders are also used in sauces, in soups, and on rice, like curry powder. These are put on the market in bottles or tins holding about one-quarter of a pound.

The kombu cut into small pieces and dried is very palatable, whether eaten dry or after immersion in hot water, having a nutty flavor. The crisp, sugared strips are excellent. Filmy sheet kombu is cooked with sauces, soups, and other dishes, like the dried, untreated strips, to impart flavor.

The chemical composition of various species of seaweed used in the manufacture of kombu is shown in the following table. The specimens were collected in the Sea of Hokkaido, and the analyses were made by Prof. K. Oshima, of the Agricultural College of Sapporo. The figures are calculated for 100 parts of original samples of kombu:

Species.	Water.	Protein.	Fat.	Soluble non-nitrogenous matter.	Fiber.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
<i>Laminaria angustata</i>	22.823	5.491	1.520	47.031	4.549	18.686
<i>longissima</i>	25.944	6.724	1.730	31.896	6.415	27.290
<i>japonica</i>	22.968	4.959	1.590	47.493	5.834	17.156
<i>ochotensis</i>	23.986	6.646	.860	41.924	6.026	20.308
<i>religiosa</i>	22.754	4.722	.820	42.845	10.196	18.633
<i>fragilis</i>	23.100	4.027	.654	40.385	7.152	24.662
<i>Arthrothamnus bifidus</i>	24.443	5.822	.738	45.572	6.437	16.988

OUTPUT AND PRICES OF KOMBU.

Official figures are available showing the quantity and value of the kelp gathered, dried, and sold by the fishermen during recent years. In 1901 the output was over 76,000,000 pounds, for which the fishermen received \$464,000.

Year.	Pounds.	Value.
1901.....	76,806,975	\$464,082
1900.....	53,750,650	301,389
1899.....	58,929,983	417,332

There appear to be no statistics of the quantity and value of prepared kombu put on the market, but the addition of 60 to 75 per cent to the cost of the raw materials would doubtless approximate the value of the manufactured article.

In Osaka the output of green-dyed kombu in 1902 was as follows: For home consumption, 4,728,640 pounds; for export to China, 7,092,960 pounds; total, 11,821,600 pounds, valued at \$132,968. The operations of one Osaka manufacturer in 1902 are represented by raw materials used, 9,900 bushels, costing \$4,950; green-dyed kombu made, 600,000 pounds, valued at \$8,550.

Following are the average wholesale prices of the various kinds of kombu in Osaka in 1903: Green-dyed kombu, good quality, 5 yen per 100 kin (133 pounds); black pulpy kombu, from 0.35 yen for cheapest to 0.70 yen for best per kamme (8.28 pounds); white pulpy kombu, from 0.80 yen for cheapest to 1.10 yen for best per kamme; white hair kombu, from 0.50 yen for cheapest to 0.80 yen for best per kamme; finely powdered kombu, 2 yen per kamme; filmy kombu, from 0.60 yen for cheapest to 1.30 yen for best per kamme; tea kombu, 1.20 yen per kamme; kombu chips (dried on fire), from 1.80 yen to 2.40 yen per kamme; sweet cake kombu, from 1.50 yen to 1.80 yen per kamme; kombu chips in soy sauce, 1.10 yen per kamme. The powdered kombu sells at wholesale for 0.08 yen per quarter-pound tins, and 0.10 yen for quarter-pound bottles.

A very large part of the supply of green-dyed kombu is exported to China. Official figures of the quantity and value of the exports for the eleven years ending in 1902 are here given. It appears that in 1901 the foreign trade was larger than in any previous year, the shipments exceeding 81,000,000 pounds.

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1892.....	57,615,465	\$497,313	1898.....	53,031,761	\$355,646
1893.....	52,871,341	469,710	1899.....	61,596,594	473,041
1894.....	55,900,505	303,514	1900.....	48,064,681	441,864
1895.....	59,773,345	315,146	1901.....	81,212,970	774,164
1896.....	46,593,772	304,792	1902.....	52,491,166	404,744
1897.....	60,153,405	415,732			

AMANORI OR LAVER.

THE SEAWEEDS AND THEIR CULTIVATION.

The Japanese have from a very early period made use of the red laver (*Porphyra*), formerly a popular food in the British Isles and sparingly eaten in the United States. The Japanese species is similar to or identical with that found in Europe and America (*Porphyra laciniata* or *vulgaris*), and grows abundantly in bays and near river mouths on all parts of the coast, but the supply is obtained almost exclusively from cultivated grounds. The local name for the seaweed is



"Amanori" or laver (*Porphyra laciniata*).

amanori, while the prepared product is called *asakusanori*. The following description of the species has been given:

Fronds livid purple, gelatinous, but firm, membranaceous, composed of a single layer of brownish-red cells; fronds 3 inches to 1½ feet long, persistent throughout the year, at first linear, but becoming widely expanded and finally much lobed and lacinate; antheridia and spores forming a marginal zone, usually borne on different individuals, or when borne on the same individual not mixed, but on separate portions of the frond. Found in all parts of the world; abounds on rather smooth stones and pebbles, near low-water mark, and when the tide falls covers them with slimy films, which make walking over them difficult. (FARLOW.)

The cultivation of *Porphyra* is one of the most important branches of the seaweed industry, and gives to Japan a unique position, for, so far as known to the writer, in no other country is this form of aquiculture practiced. The financial results are quite remarkable, and are surpassed by but few branches of agriculture, comparing the average yield per acre.

The date of the beginning of seaweed culture has not been determined, but the business is known to be very old and probably began in Tokyo Bay, which has long

had the most celebrated cultivated grounds. The next important point is Hiroshima, on the Inland Sea. The Japanese government collects very accurate statistics of this industry, and has furnished the accompanying data showing the area of the laver



Preparing brush for laver cultivation.

farms, the annual crop, etc. In 1901, the grounds under cultivation had an area of 2,242 acres, and the output was valued at \$239,536, representing about 4,769,000 pounds of dried seaweed.

Porphyra cultivation in 1901.

Prefecture.	Grounds.		Yield.	
	Number.	Area (tsubo). ^a	Quantity (kamme) ^b .	Value (yen).
Tokyo	c 3,493	1,151,314	37,478	297,723
Kanagaw	1	7,120	98	345
Aichi	12	221,800	30,250	15,527
Iwate	14	185,743	7,715	7,465
Hiroshima	846	589,627	d 376,700	126,015
Yamaguchi	6	147,800	8,154	4,515
Wakayama	2	43,027	105,000	16,800
Ehime	2	600	350	160
Fukuoka	7	147,800	485	1,996
Oita	2	3,600	e 78,820	394
Kumamoto	2	74,000	5,949	7,019
Kagoshima	8	140,000	890	1,113
Total	4,395	2,712,431	.....	479,072

^a A tsubo=4 square yards.

^b A kamme=8.28 pounds.

^c Number of families of fishermen.

^d Fresh plants.

^e Number of sheets of prepared *Porphyra*.

The following more detailed statistics show the extent of this industry in the Tokyo region during three years. In 1901 the area of the planted grounds was 951.5 acres, and the value of the crop was \$148,862, or about \$156 per acre. It is reported that in 1903 the yield was valued at 600,000 yen (\$300,000).

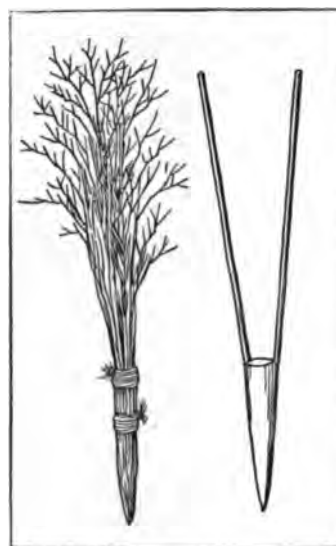
Porphyra cultivation in Tokyo Bay.

Year and district.	Families of fish-ermen.	Area of grounds.	Crop.	
			Quantity.	Value.
1899.		<i>Teubo.</i>	<i>Kamme.</i>	<i>Yen.</i>
Shiba.....	160		1,010	6,600
Fukagawa.....	161		6,602	39,918
Kyobashi.....	6		5	62
Ebara.....	2,063		15,717	98,500
Minami Katsushika.....	837		10,467	104,662
Nishitama.....	1		16	2,000
Total	3,227		33,817	249,942
1900.				
Shiba.....	153	113,850	6,670	50,100
Fukagawa.....	161	223,500	2,966	29,860
Kyobashi.....	9	10,000	40	620
Ebara.....	3,028	771,047	17,696	136,798
Minami Katsushika.....	837	93,999	5,382	33,641
Total	3,188	1,212,396	32,776	251,019
1901.				
Shiba.....	99	127,800	4,360	26,700
Fukagawa.....	476	123,083	4,479	31,432
Kyobashi.....	6	15,900	810	7,482
Ebara.....	2,030	781,965	12,336	107,940
Minami Katsushika.....	883	102,566	15,489	123,809
Total	3,493	1,161,314	37,474	297,723

In October and November (in Tokyo Bay) the grounds are prepared for the seaweed crop by sinking into the muddy bottom, in water up to 10 or 15 feet deep at high tide, numerous bundles of bamboo or brush. These bundles are prepared on shore and taken to the grounds in boats at low tide, one or two men constituting a boat's crew. The bundles of brush are planted in regular lines, deep holes being made for them by means of an elongated conical wooden frame with two long, upright handles, which is forced into the mud by the weight of the fisherman.

The object of these lines of brush is to intercept and afford a lodgment for the floating spores of *Porphyra*. The spores become attached to the twigs and grow rapidly, so that by the following January the plants have attained full size and are harvested from January to March, being cut from the brush as they grow. They die about the time of the vernal equinox, and the active business is at a standstill until the ensuing fall. During summer, however, the old brush is removed from the grounds, and fresh material is collected and prepared.

The best grounds for growing *Porphyra* are in great demand, and the fishermen are often in conflict over them. The local



Bundle of brush and conical frame used in planting brush on soft bottom.



Planting bundles of brush on which laver is to grow.

river carried down with it a large quantity of gravel, its mouth advanced more and more into the sea, and, the water near Asakusa becoming too fresh, the plant disappeared. Owing to this circumstance, the above-described mode of cultivation was instituted. The plant has, however, preserved its former name of *Asakusa-nori*.

PREPARATION AND UTILIZATION OF PORPHYRA.

While small quantities of amanori are eaten fresh, most of the crop is sun-dried before reaching the consumer. When gathered from the twigs, the seaweeds contain sand, mud, and other foreign substances, to remove which they are washed in tanks or barrels of fresh water. After being picked and sorted they are chopped fine with hand knives. The chopped fronds are then spread on small mats of fine bamboo splints and made into thin sheets, a uniform size being attained by means of a frame applied to the mats. The mats are first placed

governments lease the planting privileges. In Tokyo, where five classes of licenses are issued, depending on the yield of the grounds, the license tax is from 0.20 to 0.70 yen.

It is reported that the quality of the cultivated *Porphyra* depends very much on the weather, and is best when frequent rains and falls of snow have rendered the shallow water more or less brackish. Too large a proportion of sweet water is unfavorable to the growth of the plant. A century or two ago amanori was gathered in large quantities at the mouth of the Sumidagawa, near Asakusa in Tokyo; but as the

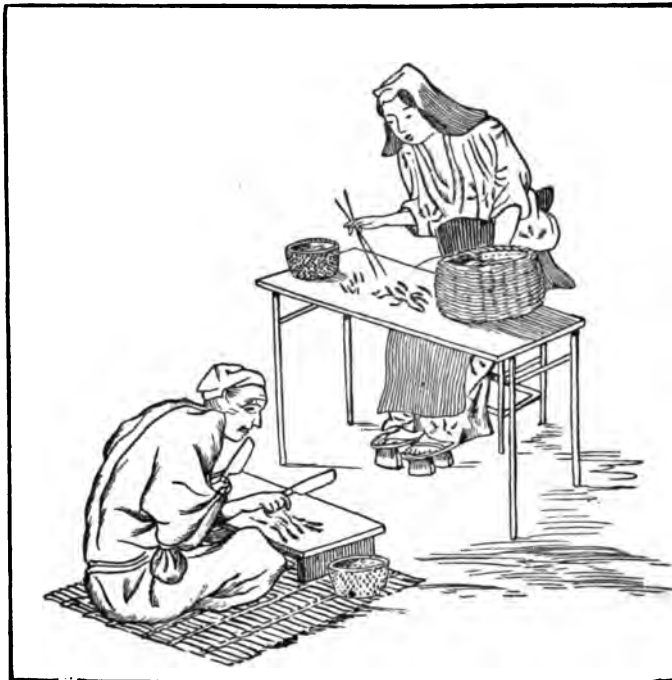


Washing laver prior to sorting and cutting.

in piles and later spread on inclined frames in the open air. Drying proceeds quickly and when complete the mats are stripped from the mats and, after pressing to make them flat, are arranged for market in bundles of ten. The sheets are about 10 by 14 inches, thin and flexible like writing paper, and have a dark mottled brownish-purple color and a glossy surface.

Before the dried *Porphyra* is eaten it is put over a fire to make it crisp, its color changing to green under this treatment. It is then crushed between the hands and dropped into sauces, soups, or broths to impart flavor.

Pieces dipped in sauce are also eaten alone and there are various other culinary uses of this article, which is found in every Japanese kitchen. Recently it has



Sorting and cutting laver.

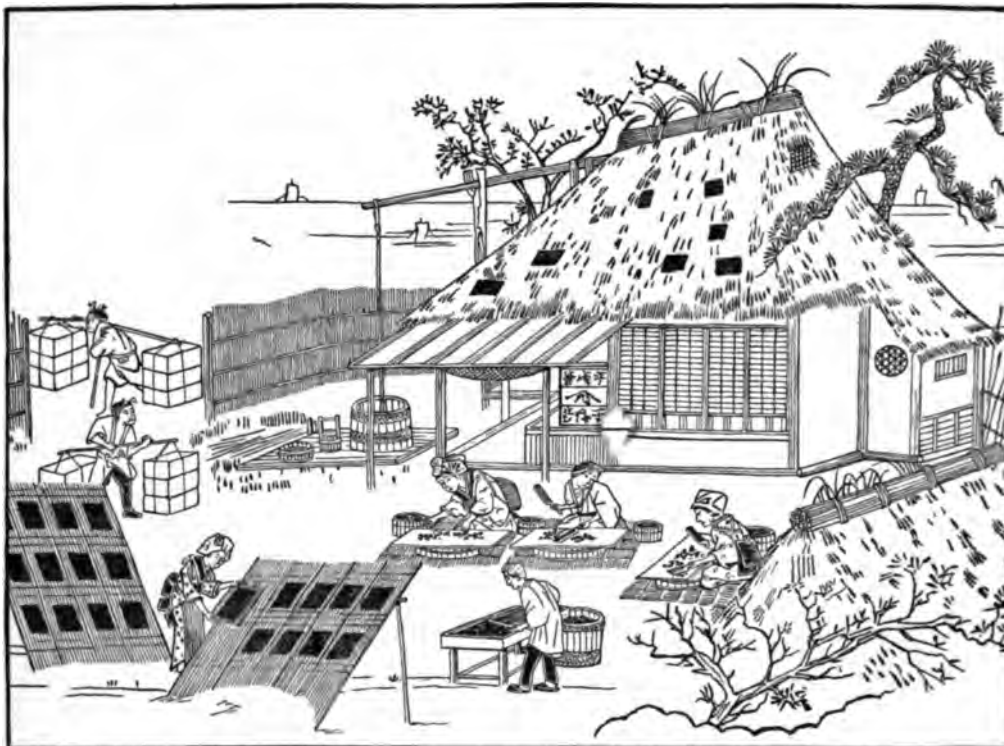


Preparing laver sheets.

been boiled with Japanese (soy bean) sauce and put up in tins. At railway stations, at street stands, and in the push carts of vendors, as well as in private families, a common seaweed food article in all parts of Japan takes the place of a sandwich in America, and is called *sushi*. On a sheet of amanori boiled rice is spread, and on the rice strips of meat or fish are placed; the whole is then made into a roll and cut into transverse slices. From the following analyses furnished by the Imperial Fisheries Bureau it appears that amanori is rich in proteid matter and is a nutritious food:

Composition of Porphyra.

Locality.	Weight of 10 sheets.	Water.	Protein.	Fat.	Ash.
	<i>Grams.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Suna	41	14.575	32.444	0.700	9.000
Do.....	37	16.396	35.625	.500	9.340
Fukagawa.....	32	20.415	36.263	1.210	8.880
Shinagawa	30	15.475	34.350	.650	10.685

The preparation of *Porphyra*. From a Japanese print.

SEAWEED IODINE.

GENERAL INFORMATION.

Although the manufacture of iodine from seaweeds is of comparatively recent origin in Japan, that country now supplies a considerable part of this commodity used in the world, supplanting Scotland, which formerly produced most of the iodine extracted from marine plants. Up to ten years ago the business was very profitable, but, owing in part to competition and in part, perhaps, to a scarcity of suitable raw material, it has become less remunerative.

The chief localities for the manufacture of iodine are in Hokkaido and the prefectures of Chiba, Kanagawa, Yamaguchi, and Shizuoka. No general statistics are available, and it is not known how extensive the business now is, but the following tract from the Yokohama Shimpō gives some idea of its importance (1903):

Although the manufacture of iodine in Japan can not as yet be said to be carried on extensively, it is a matter for congratulation that it has been so far advanced as to put a complete stop to the importation of the foreign article, and the manufacturers in all parts of the country are making pretty good profits out of the business. The general tendency is that, with the increase of demand for the element, the business would become one of the most important industries in the Empire. In the case of Kanagawa prefecture, Mr. Sudzuki, of Hayama, near Yokohama, started the manufacture of iodine



"Kajime" (*Ecklonia cava*).



"Arame" (*Ecklonia bicyclis*).

that place a few years ago with a small capital. The business has now proved so successful that he has enlarged the business to such an extent as to enable him not only to meet the demand at home but also to export some of the product to foreign countries. Probably this is now the largest factory of the kind in Japan. It is said that, as a result of careful investigations, he has now discovered that a residue left after extracting iodine from seaweed can be used as material for making nitrate of soda and chloride of sodium, and that he at present turns out some 12,000 yen worth of the latter article in a year. The difficulty, however, seems to be that it is no easy work to collect such a quantity of seaweed as is required in the manufacture.

THE ALGÆ UTILIZED.

Iodine exists in many species of marine algæ, and in Japan is obtained from about ten species, representing three or four genera. In Hokkaido only "kombu" (Gelidium) of various kinds is used, but in other sections the seaweeds in greatest favor

are "kajime" (*Ecklonia cava*), "arame" (*Ecklonia bicyclis*), and "ginbaso" (*Sargassum*). The following table, based on the analyses of the Imperial Fisheries Bureau, shows the proportion of iodine in different algæ. It will be seen that the percentage of iodine in *Sargassum* is very small, while kelp (*Laminaria*) contains by far the largest percentage in a given quantity of ash and *Ecklonia* the largest percentage in the fresh weed.

Analyses of seaweeds from which iodine is extracted.

Japanese name.	Scientific name.	Locality.	Iodine in raw weed.	Ash in 100 parts weed.	Iodine in 100 parts ash.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Kajime.....	<i>Ecklonia cava</i>	Chiba Prefecture	0.232	54.828	0.424
Do.....	do.....	Yamaguchi Prefecture.....	.251	47.223	.581
Arame.....	<i>Ecklonia bicyclis</i>	do.....	.271	50.904	.531
Ginbaso.....	<i>Sargassum</i> sp.....	do.....	.054	52.042	.104
Do.....	do.....	Chiba Prefecture.....	.029	51.941	.057
Kombu.....	<i>Laminaria angustata</i>	Hokkaido.....	.180	18.686	.990
Do.....	<i>Laminaria longissima</i>	do.....	.173	27.290	.634
Do.....	<i>Laminaria japonica</i>	do.....	.106	17.156	.619
Do.....	<i>Laminaria ochotensis</i>	do.....	.188	20.308	.922

The iodine salts are not uniformly distributed in the different parts of the plants, and moreover vary in quantity from month to month. These points are brought out in detail in the following interesting series of analyses of "kajime" (*Ecklonia cava*) from the Chiba coast, made by the Imperial Fisheries Bureau:

Analysis of Ecklonia cava.

	March.	April.	May.	June.	July.	August.	September.
Young stalk:							
Iodine in 100 parts of material.....	0.061	0.067	0.093				0.177
Ash in 100 parts of material.....	45.42	46.73	44.28				45.68
Iodine in 100 parts of ash.....	.134	.144	.209				.388
Young leaf:							
Iodine in 100 parts of material.....	.063	.060	.084				.143
Ash in 100 parts of material.....	47.27	45.75	43.17				48.90
Iodine in 100 parts of ash.....	.134	.130	.195				.290
Old stalk:							
Iodine in 100 parts of material.....	.118	.118	.147	0.255	0.216	0.142	.267
Ash in 100 parts of material.....	46.77	44.64	48.76	49.95	42.95	48.30	45.07
Iodine in 100 parts of ash.....	.252	.263	.302	.507	.507	.346	.592
Old leaf:							
Iodine in 100 parts of material.....	.101	.114	.076	.294	.294	.142	.592
Ash in 100 parts of material.....	48.42	43.64	45.28	50.16	41.00	54.12	43.89
Iodine in 100 parts of ash.....	.209	.261	.167	.586	.717	.262	.528

The seaweeds are gathered chiefly in summer, some from the shores where they have been washed, some from submerged rocks and small stones by means of a knife attached at right angles to a bamboo pole. It is reported that the supply of algæ most valuable for iodine manufacture is diminishing.

TREATMENT OF THE ALGÆ.

The weeds are dried on the shores in the sun, then heaped and burned. The ash is collected and either sold to the manufacturers or treated by the fishermen themselves. Following is an outline of the reducing process:

The ash is washed with fresh water, and the soluble parts are thus extracted. The extract is then evaporated in iron pans over a fire, and a concentrated brine is obtained. Besides iodine, this brine contains potassium chloride, sodium chloride, magnesium chloride, and calcium sulphate, which during further evaporation crystallize out, leaving magnesium and potassium iodides in solution. The extract is finally placed in a glass or porcelain retort with sulphuric acid and potassium permanganate, and boiled, the iodine passing over and depositing in crystals. This product, however, is not strictly pure, and refining is necessary. Refining factories are located in Tokyo and Osaka.

The fishermen send their ash to the manufacturers in straw bags like those used for rice. As the ash is sold by weight, the fishermen are said to be not over careful to exclude sand and other foreign matter.

The output of crude iodine in Hokkaido in 1901 was 12,405 pounds, valued at \$15,866.

OTHER JAPANESE ALGÆ AND THEIR USES.

The foregoing are the principal seaweeds and their applications in Japan, but there are many other species utilized in various ways. Many algæ are not objects of trade, but are employed for home purposes, and the annual consumption of these is very large. Some are used for making jellies, some as vegetables, some as salads, some as condiments, and some for decorative purposes. Large quantities are also used for fertilizers. In few countries is agriculture more thoroughly intensive than in Japan, and the need and demand for fertilizers are most pronounced. Among the minor species which are especially sought and are most used, the following may be mentioned. For the information concerning them the writer is chiefly indebted to Dr. K. Oku, chemist of the Imperial Fisheries Bureau, and to the paper by Yendo on "Uses of Marine Algæ in Japan."

"Arame" (*Ecklonia bicyclis*).—This alga, which is employed in the manufacture of iodine, is also used as food and fertilizer. It grows on reefs on the coast of various provinces, and is gathered from March to July. Its greatest length is about 2 feet. The chemical composition of the plant, as determined by Prof. Dr. Edward Kinch, formerly of the Agricultural College of Tokyo University, is water, 13.17 per cent; protein, 8.99 per cent; carbohydrates, 45.09 per cent; fiber, 7.40 per cent; and ash, 24.74 per cent. "Arame" is chiefly eaten as an ingredient of soups, as a salad, or mixed with soy-bean sauce. In localities where it grows abundantly it is sometimes spread on the land. The dried stem is very hard and may be used as handles for knives or other such implements. "Kajima" (*Ecklonia cava*) is not used for food, but is extensively employed for the decoration of houses on festive occasions.

"Hijiki" (*Cystophyllum fusiforme*) grows on rocks that are exposed at low tide, and is gathered therefrom between January and May. In January and February, when it is very small and tender, its quality is better than in other months; the largest size attained is 6 to 8 inches. This species is sun dried and is ready for use after boiling in fresh water or cooking with soy-bean sauce. Following is the chemical composition, according to Doctor Kinch: Water 16.40 per cent, protein 8.42, carbohydrates 41.92, fiber 17.06, and ash 16.20.

"Wakame" (*Undaria pinnatifida*) is dried and sold in bales, and is a common food article in parts of Japan. Before being used it is washed with fresh water, and then eaten as a salad, cooked with soy-bean sauce or put in soups. Yendo states that the peasants in northern Japan cut off the ripe sporophylls (fronds bearing sacs) and press them into a slimy liquid which is eaten after mixing with boiled rice. In some places "wakame" is treated much like "ama-nori" before being eaten; that is, it is put in a basket or tray with a wire mesh bottom and parched over a slow charcoal fire. Another method of preparation, peculiar to the province of Shima, is to cut the dried weed into 1-inch lengths and put them in cans or other vessels with sugar. The thick root of "wakame," called "mehibi," is often dried, shaved, or cut into thin slices, and eaten with sauce (miso). "Wakame" usually grows on rocks in currents or where the water is not sluggish, at depths of 20 to 40 feet. It is gathered in many provinces during winter by means of long poles terminating in a radiating cluster of long teeth or prongs, the weeds being torn from their attachment by a twisting motion.

"Suizenji-nori" (*Phyllocladus sacrum*).—This species derives its name from the place where it is prepared. Suizenji is a park in Higo Province near Kumamoto, belonging to an old lord of the famous Hosokawa family. In this park is a large fresh-water pond, and at the lower end of this pond is a small lake from which "suizenji-nori" is gathered, and on the shore of which it is dried.

This product is ordinarily eaten with raw fish (*sashimi*); the dry weed is soaked in fresh water, and after it has swelled boiling water is sprinkled over it and then soy-bean sauce is added. In the time of the feudal system this preparation was regularly presented to the local daimyo.

"Awo-nori" (*Enteromorpha compressa*, *E. intestinalis*, and *E. linza*) grows in river mouths where fresh and salt water mix, and is cropped from November to April, being preserved by drying in the sun in sheets or bunches. Dr. O. Kellner gives the following analysis of dried *E. compressa*: Water 13.60 per cent, protein 12.41, fat and carbohydrates 52.99, fiber 10.58, and ash 10.42. "Awo-nori" is eaten after being gently heated over a charcoal fire and crushed or powdered; it has a very good flavor, and is used chiefly as a condiment. The first two species are abundant on the United States coasts.

"Aosa" (*Ulva lactuca*), the well-known sea lettuce of the United States, is much used in Japan in the same way parsley and lettuce are often employed by Americans—that is, as a garnishment for meats, fish, and salads.

"Miru" (*Codium tomentosum*, *C. mucronatum*, *C. lindenbergeri*).—These species grow on rocks and stones along the shores of various provinces, and are cropped in April or May. After drying they are preserved in ash or salt. They are prepared for food by boiling or baking in water, and are put in soups; or, after washing, by mixing with soy-bean sauce and vinegar.

"Haba-nori" (*Phyllitis fasciata*).—This plant is prepared for use after the manner of "awa-nori" (*Porphyra*), principally by peasants of the provinces of Awa and Sagami. The young fronds are dried in the sun in sheet form and subsequently parched, powdered, and mixed with soy-bean sauce.

"Matsuma" (*Chordaria abietina*).—This species, which resembles a spray of fir, abounds in northern Japan, and is consumed in large quantities by the peasantry.

It is preserved by packing in salt, and is cooked with soy-bean sauce. Yendo refers to an interesting use to which it is put, namely, the preservation of mushrooms. The mushrooms are washed in fresh water and then packed in tight barrels in layers alternating with layers of salted seaweed.

"Mozuku" (*Mesogloia decipiens*) reaches a length of about 1 foot, and is gathered in April or May while young. It is preserved by salting, and is eaten after washing out the salt and immersing in soy-bean sauce or vinegar.

"Hondawara" (*Sargassum enerve*) grows on reefs on the seacoasts, and is used as fertilizer after being piled on the shore and allowed to decompose. When the plant is young it is eaten in soup or with soy-bean sauce. It has a bright green color when dried, and has been employed from a very remote time, intertwined with *Laminaria*, in New Year's Day celebrations. Numerous other species of *Sargassum*, collectively called *mo* or *moku*, are employed as fertilizer in middle and southern Japan.

"Somen-nori" (*Nemalion vermiculare*) grows on rocks on various parts of the coast, being particularly abundant in San-in, Hoku-roku, and the northeastern districts, and rarely found in the Sea of Tokaido. Its length is 5 to 12 inches. It is generally preserved by simply drying, or by mixing with ash or salt, and is eaten in soup or after mixing with vinegar and soy-bean sauce. In some places "umi-zomen" (*N. lubricum*) is dried, bleached, and eaten like the foregoing species.

"Tosaka-nori," meaning crest-like seaweed (*Kallimonia dentata*), grows on reefs of Kozu Island and also in the provinces of Ise, Shima, and Higo, at depths of 8 feet to several fathoms, and is collected on the shores in August and September after a strong wind. It is preserved by drying, and is eaten as a condiment or mixed with soy-bean sauce.

"Tsuno-mata," "hosokeno-mimi" (*Chondrus crispus*, *C. ocellatus*, etc.).—The well-known "Irish moss" occurs on the coast of Japan and, with related species, is employed in a variety of ways, after first being dried in the sun. When boiled to form a jelly, these plants are used as food, as starch for stiffening linens, as a washing medium, and as a substitute for agar-agar.

"Ogo-nori" (*Gracilaria confervoides*).—According to Yendo, this is a favorite seaweed for garnishment in Tokyo, after being treated with lime water or dipped in hot water to change the color from pink to green.

Other Japanese algæ which are dried and eaten or utilized in various other ways are: "Cata-nori" (*Gigartina teedii*), "comen-nori" (*Grateloupia affinis*), "mukade-nori" (*Grateloupia filicina*), "makuri" (*Digenea simplex*), "ego" (*Campylaeophora hypneoides*), "okitsu-nori" (*Gymnogondrus flabelliformis*), and "tosaka" (*Sarcodia* species).

THE UTILIZATION OF SEaweEDS IN THE
UNITED STATES.

By HUGH M. SMITH,
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With seaweed resources certainly not inferior to those of Japan or any other country, and probably much superior, the United States may be said practically to ignore these valuable products except at a few points on its extensive coast. Statistics recently gathered give the paltry sum of \$35,000 as the value of the marine algæ prepared in the United States in one year. The business is practically restricted to Massachusetts, and is addressed to a single species, the "Irish moss" (*Chondrus crispus*). Considerable quantities of seaweeds are used as fertilizer on farms adjacent to the coast, but this is not a commercial enterprise. In Monterey and Santa Barbara counties, Cal., the Chinese fishermen dry certain algæ for food, medicine, and fertilizer; in 1899 the quantity prepared was 35,824 pounds, valued at \$896.

There is undoubtedly a good opportunity to develop the seaweed industry of every section of the United States coasts, and to establish a profitable trade in the various species and preparations of marine algæ along the new lines indicated in the foregoing paper on the Japanese seaweed industry, as well as by increasing the output of the species already sparingly utilized. To this end the following information and suggestions are offered in regard to some of the useful algæ of the United States.

IRISH MOSS, OR CARRAGEEN (*Chondrus crispus*).

This alga is found from North Carolina to Maine, being especially abundant north of Cape Cod, growing on rocks just below low-water mark. The fronds are 3 to 6 inches long and usually purple, but when growing exposed to a bright light are yellowish-green. There are various other algæ considered to be quite as useful as *Chondrus crispus* for the purposes for which the latter is gathered. Among them are several species of *Chondrus* found on the California coast; various species of *Gracilaria*, found from Key West to Cape Cod and also on the Pacific coast; *Eucheuma isiforme*, found in the Key West region; and *Gigartina mamilliosa* and numerous other species of *Gigartina*, which closely resemble *Chondrus* and abound on our east and west coasts.

The plant has from time to time been gathered on various parts of the New England coast, but at present is utilized at only a few localities in New Hampshire and Massachusetts, the principal place being Scituate, where it would seem the business has always been more important than at any other place on our coast. It is recorded (Wilcox, 1887) that prior to 1835 the small quantity of Irish moss used in this country was imported from Europe and sold here at one to two dollars a pound, and that in the year named Dr. J. V. C. Smith, at one time mayor of Boston, made it generally known that the "moss" which abounded on the Massachusetts shores

was the same as that which was imported at such a high price. From that time to the present Irish moss has been prepared at Scituate, and in 1879 was the leading marine production. By 1853 the price, which in 1835 was \$1 a pound, had dropped to 25 cents, and by 1880 to 3 or 3½ cents. About 1880 the average annual yield was 5,000 barrels of dried weed, averaging 90 pounds to the barrel.

The methods of conducting the business have changed but little in many years, and the simple apparatus required remains the same as in the early days of the industry. Mr. T. M. Cogswell, of the Bureau of Fisheries, has furnished the data on which the following account is based.

A small part of the crop is gathered by hand, but most of it is torn from the rocks by means of rakes used from boats. The rakes are made especially for the purpose, and have a 15-foot handle and a head 12 to 15 inches wide, with 24 to 28 teeth 6 inches long and an eighth of an inch apart.



Irish moss (*Chondrus crispus*).

The gathering season extends from May to September. If the rocks are not scraped too clean in the early part of the season, it is said to be possible to get two crops in some of the warm, sheltered coves, where the alga grows much faster than in the more exposed places.

The output in recent years has varied considerably, owing chiefly to the inclination or disinclination to engage in the business. Some years a large number of people seem moved by a desire to gather the weed, while other seasons only a few go into the business. Occasionally heavy storms do damage by tearing the plant from the rocks and scattering it along miles of beach.

There is said to be a scarcity at

times, owing, it is supposed, to too active gathering the previous season, the rocks being almost completely denuded.

In the preparation and curing of Irish moss fair weather and much sunshine are prime requisites. When first brought ashore, the plants are washed in salt water and then spread upon the sandy beach to dry and bleach. After twenty-four hours in good weather they are raked up and again washed and again spread on the beach to dry. Three washings are usually sufficient for complete cleansing, curing, and bleaching, but as many as seven are sometimes given. After the final washing the plants are left in the sun, the entire process requiring about two weeks of good weather and warm sunshine. The plants gradually fade, and by the time the curing is finished they are white or straw colored. Two more weeks are then required to sort and prepare the product for shipping.

Great care has to be exercised in the curing to prevent the rain from spoiling the crop, and when a storm is impending the moss is hastily raked in piles and covered with canvas. Should it chance to get wet in the last week of its curing, it is practically ruined.

The moss is sent to market in barrels holding 100 pounds, and the first of the crop is usually shipped in August. The product has a wide distribution in the United States and Canada, a part of it going to druggists and grocers, but much the larger part to brewers and firms handling brewers' supplies. The wholesale price was 4 to 4½ cents per pound in 1902, and 5 to 5½ cents in 1903.

From information regarding this business recently gathered by the Bureau of Fisheries, it is seen that 136 men were employed in gathering this plant in 1902; the boats, rakes, and shore property used were valued at over \$12,000; and the quantity of dried algæ sold was 740,000 pounds, with a market value of \$33,300. In 1898 the output was 770,000 pounds, valued at \$24,825.

Statistics of the Irish moss industry of New England for 1902.

Locality.	Men.	Boats.		Rakes.		Shore property.	Product.	
		Num-ber.	Value.	Num-ber.	Value.		Pounds.	Value.
Massachusetts:								
Scituate	100	15	\$1,873	75	\$375	\$5,000	500,000	\$22,500
North Scituate	5	5	200	5	25	200	30,000	1,350
Cohasset	10	12	480	10	50	600	60,000	2,700
Plymouth Harbor and White Horse Beach	15	14	730	15	75	700	100,000	4,500
New Hampshire:								
Rye Harbor	6	8	240	6	30	1,500	50,000	2,250
Total	136	54	3,523	111	555	8,000	740,000	33,300

Irish moss of excellent quality is now placed on the market in 1-pound and half-pound boxes, selling at retail for 45 cents and 25 cents, respectively; it is intended chiefly for making blanc mange, and is used as follows: Soak half a cup of dry moss in cold water for five minutes, tie in a cheese-cloth bag, place in a double boiler with a quart of milk and cook for half an hour; add half a teaspoonful of salt or less, according to taste, strain, flavor with a teaspoonful of lemon or vanilla extract if desired, and pour into a mold or small cups, which have been wet with cold water; after hardening, eat with sugar and cream. To make a demulcent, for coughs, place moss in cold water and heat gently until the liquid is of a sirupy consistency, then strain and add sugar and lemon juice to suit taste.

Other uses to which it has been put are the making of jellies and puddings, the clarifying of beers and the sizing of fabrics.

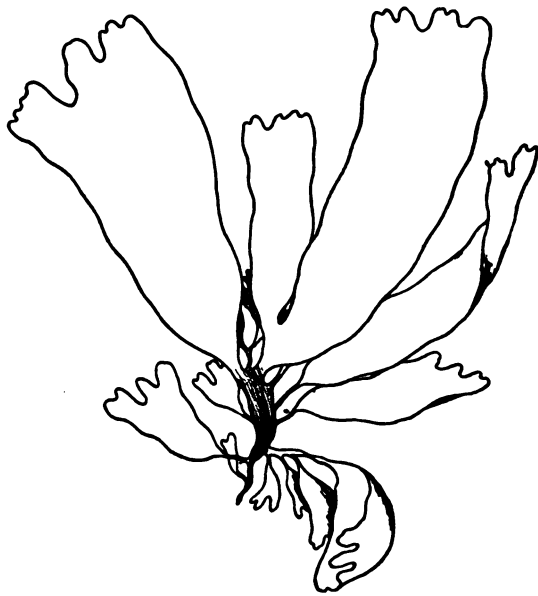
VEGETABLE ISINGLASS FROM GELIDIUM CORNEUM.

The identical species of alga from which the Japanese prepare their "kanten," or vegetable isinglass, grows in abundance on our Pacific coast, and is also found at various places between Florida and Maine. Other species (*G. coulteri*, *G. cartilagineum*) exist on the coast of California and about the Philippine Islands. The high price of this product and the large consumption of it and fish isinglass in the United States warrant the belief that a profitable business could be established.

Isinglass made from *Gelidium* is one form of agar-agar, now so extensively used in making culture media in bacteriological work. Other sources are the Australian and Asiatic plants, *Eucheuma spinosum*, *Gracilaria lichenoides*, *G. tenax*, and other related species, which yield the products known in commerce as agar-agar, agar-agar gum, agal-agal, Bengal isinglass, Bengal isinglass gum, Ceylon moss, Ceylon agar-agar, Chinese moss, etc.

Vegetable isinglass is composed largely of gelose or pararabin, a substance remarkable for its gelatinizing properties, which exceed those of any other known product. It is insoluble in cold water, alcohol, dilute acids, and alkalis; its melting point is 90° F; it has eight times the gelatinizing power of ordinary gelatine and isinglass; and 1 part to 500 parts of boiling water forms a jelly on cooling. Gelose

jelly keeps well, but owing to its high melting point is not so well adapted for food preparations as some other jellies.



Dulse (*Rhodymenia palmata*).

DULSE (*Rhodymenia palmata*).

The dulse is found along the shores of all the States from North Carolina to Maine, and is very abundant in New England. It is rough-dried in the sun, and eaten dry as a relish. It is met with in stores in the coastwise towns of the Eastern States, but is usually brought from the Canadian provinces, and has not figured in recent statistical canvasses of the New England fisheries. Other species of this genus grow on the west coast of the United States. Several other algæ known as dulse in Europe, and used in the same way as *Rhodymenia*, are represented by various species on the Pacific coast of

America. In Ireland, dulse is eaten with butter and fish, and is also boiled in milk with rye flour (Simmonds, 1883). Some gentlemen in the Scotch Highlands known to Stanford (1884) are quoted as holding that "a dish of dulse boiled in milk is the best of all vegetables." Swan (1893) states that dulse is common on the northwest coast and is an article of diet among the Haida Indians of Queen Charlotte Island and other tribes, although not in general use. Like the green and purple laver used by the same Indians, it is dried and compressed into blocks, and as needed is sliced with a sharp knife, soaked in fresh water, and boiled. Swan partook of an Indian meal of dulse boiled with halibut and found it very palatable.

LAVER (*Porphyra laciniata*).

This alga is found in abundance along the entire coast, but is not collected except sparingly by Chinese, who obtain most of their supply from Asia. It was recorded in 1876 by Farlow that laver was imported from China by the Chinese living in this country, even by those as far east as Massachusetts, although the plant is common on the Massachusetts shores. The considerable demand for *Porphyra* among oriental people in the United States should be supplied from local sources, the algæ being prepared after the Japanese method or by simple washing and drying.

In Ireland, where it is called "sloke," laver is boiled and served with butter, pepper, and vinegar as a dressing for cold meat.

GIANT KELP; GREAT BLADDER-WEED (*Nereocystis lütkeana*).

This most remarkable plant, which attains an enormous length, grows on the Pacific coast from Monterey Bay northward. Swan (1893) writes as follows regarding it in the Puget Sound region:

The *Nereocystis* of the northwest coast is said, when fully grown, to have a stem measuring 300 feet in length, which bears at its summit an air bulb, from which a tuft of upward of 50 long, streamer-like leaves extend, each of which is from 30 to 40 feet in length. The stem, which anchors this floating mass, though no thicker than a common window cord, is of great strength and flexibility, and has for ages been used by the natives as fishing lines, being first cut of the required length, which is where the stem begins to expand into the hollow tube, and varies from 10 to 15 fathoms, then soaked in fresh water in a running brook until it is nearly bleached, then stretched, rubbed to the required size, and dried in the smoke in the lodge. When dried it is very brittle, but when wet it is exceedingly strong, and equal to the best flax or cotton fishing lines of the white fishermen. These pieces, varying from 10 to 15 fathoms each, are knotted together to the required length of 80 fathoms, required in the deep-water fishing around the entrance to Fuca Strait, or 200 fathoms at Queen Charlotte Islands, British Columbia, where the natives take the black cod at that profound depth.

Until within a few years the coast Indians used the upper or hollow portion of these great kelp stems as receptacles for holding dog-fish oil, which, together with the paunches of seals and sea-lions and whale gut, properly prepared, were the utensils found in every house for holding the family supplies of whale, seal, or salmon oil which are used as articles of food, or for dog-fish oil, which is used for trading purposes only. Now, however, the Indians are using coal-oil cans, barrels, and other utensils easily procured from the white traders, and the use of kelp for holding oil is nearly abandoned.

Among my collections for the National Museum in 1885 I received a number of specimens of



Giant kelp (*Nereocystis lütkeana*).

this kelp which had been used for dog-fish oil. I split one open and found that the oil had hardened the inside of the kelp tube to the consistency of leather. This specimen I washed with soap and water, then wiped it to remove the moisture, and then rubbed and manipulated it after the manner used by natives in dressing deer skins, and when perfectly dry by this process of continual rubbing, it was soft and flexible, presenting an appearance of wash leather, but if allowed to dry without manipulation it would be hard and brittle. A party of coast Indians were camped on the beach at Port Townsend, and, at my request, they showed me their method of preparing kelp for holding oil. The great stems of the *Nereocystis* are covered with a thin coating of silice, which is carefully peeled off as one might peel the skin from an apple; only the hollow or upper part of the stem is used. When the skin is removed the tube is placed above the fire and smoke in the lodge, and, as it dries, the salt it contains exudes on the surface; this is carefully removed by rubbing, which also serves to soften the kelp and render it pliable. It is then again placed over the fire, and the process continued until the salt is removed; then the tube is blown up like a bladder and allowed to dry until it will retain its shape, and it is then filled with dog-fish oil and is ready for market.

The rude and simple experiments I made with this giant kelp convinced me that it is capable of being converted into articles of commercial value, but as I had not the means of conducting experiments, or of procuring the machinery requisite to the manufacture of the kelp products on a scale of commercial importance, I have allowed the matter to rest until some one of enterprise and capital may be found ready to continue these investigations.

* * * * *

During a residence of many years in the vicinity of Cape Flattery, at the entrance of Fuca Strait, I have had ample time and opportunity to observe the great masses of the giant kelp and other marine plants which are torn up by the roots every fall by the storms and piled by the waves along the beach at Neah Bay. I have frequently noticed, when a mass of this kelp has been thrown into a pool of fresh water, that in a few days it is covered with this slippery substance, which Stanford (1884) has named algin, and I think that the *Nereocystis* is rich with this valuable ingredient. The supply of the raw material is practically unlimited, and if attention shall be directed to the valuable uses to which this plant and other algae may be put, I feel confident that a new and important industry will be developed.

FOOD PREPARATIONS FROM THE KELPS.

Numerous species of *Laminaria* exist on the northern parts of both coasts of the United States. The only use to which the plants are now put is for fertilizer. There is no question but that some of the Japanese "kombu" preparations would meet with ready sale, not only among Chinese and Japanese in the United States and its island possessions, but also among natives. The forms of "kombu" which are likely to prove most acceptable to the American palate are the powders, films, and dried sticks. It occurred to the writer that the crisp sticks might be broken into small pieces and serve as a breakfast dish, like oatmeal or other cereal. An Osaka manufacturer accordingly prepared some in the form of small rectangular flakes, which, when moistened with milk or hot water, formed a very wholesome and agreeable dish.

KELP AND OTHER SEAWEEDS CONTAINING IODINE.

Algae representing species identical with or similar to those used in Scotland, France, and Japan in the manufacture of iodine abound on the northern coasts of the United States, but are never used for this purpose. In view of the large consumption of iodine in the United States and the facility with which it may be prepared, in crude form, at many places on the New England and North Pacific

coasts, it is quite remarkable that no one has undertaken the manufacture of this product. Supplementary to the outline of the Japanese method of preparing iodine, it is therefore deemed advisable to give some account of the iodine industry in Scotland.

Nearly all marine algæ contain iodine, but a few have such a comparatively large quantity that they are utilized almost exclusively. In the early days of iodine and soda manufacturing on the Scotch coasts, only "rockweeds" or "wrack," technically known as cut-weed kelp, were used; they represented three species—namely, *Fucus vesiculosus*, *F. serratus*, and *Ascophyllum nodosum*. Stanford (1884) gives an interesting historical account of this industry:

This crude substance (kelp), which for many years made the Highland estates so valuable, was at first made as the principal source of carbonate of soda. At the beginning of the century it realized £20 to £22 per ton, and the Hebrides alone produced 20,000 tons per annum. The importation of barilla then began, and for the twenty-two years ending 1822, the average price was £10 10s. The duty was then taken off barilla, and the price of kelp fell to £8 10s.; and in 1823, on the removal of the salt duty, it fell to £3, and in 1831 to £2. It was used up to 1845 in the soap and glass factories of Glasgow, for the soda. Large chemical works were then existing in the island of Barra for the manufacture of soap from kelp, and a very large sum of money was lost there. In the meantime, soda was being largely made by the Le Blanc process, and superseded kelp, which was always a most expensive source, yielding only about 4 per cent, often less than 1 per cent. It must have cost the soap-makers what would be equal to £100 per ton for soda ash, the present price of which is £6.

The manufacture of iodine and potash salts then began to assume some importance, but the kelp required was not the same, that which contained the most soda containing the least iodine and potash. Chloride of potassium, the principal salt, was at one time worth £25 per ton. The discovery of the Stassfurt mineral speedily reduced this price to about a third, and the further discovery of bromine in this mineral also reduced the price of that element from 38s. per pound to 1s. 3d., its present price. The amount of bromine in kelp is small, about a tenth of the iodine, and not now worth extracting. Large quantities are now produced in Germany and America. More recently, the manufacture of iodine from the caliche in Peru has attained large proportions, and has so far reduced the price of that article as to make its manufacture from kelp unremunerative.

* * * The plants were cut at low tide, floated ashore, dried and burnt. * * * This kelp, burnt into a dense fused slag, contained the most carbonate of soda, and was that variety which employed so many poor crofters and cotters, and enriched so many Highland lairds. It is now worthless, and the *Fuci*, which hang from the rocks at low water in luxurious festoons, are now entirely unutilized.



Rock weed (*Fucus vesiculosus*).

From the following table given by Stanford, showing the quantity of iodine in various seaweeds, the preponderating value of *Laminaria* for iodine manufacturing will be apparent:

Iodine in sun-dried seaweeds.

Species.	Per cent.	Pounds per ton.	Species.	Per cent.	Pounds per ton.
<i>Laminaria digitata</i> , "tangle;" stem..	0.4535	10.158	<i>Fucus serratus</i> , "black wrack".....	0.0856	1.807
frond.....	.2946	6.599	vesiculosus, "bladder wrack".....	.0297	.665
stenophylla; stem.....	.4028	9.021	<i>Halidrys siliquosa</i> , "sea oak".....	.2131	4.773
frond.....	.4777	10.702	<i>Hymanthalia lorea</i> , "sea laces".....	.0892	1.998
saccharina, "sugar wrack".....	.2794	6.253	<i>Rhodomenia palmata</i> , "dulse".....	.7120	1.594
bulbosa.....	.1966	4.403	<i>Chordaria flagelliformis</i>.....	.2810	6.294
<i>Ascophyllum nodosum</i> , "knobbed wrack".....	.0572	1.281	<i>Chorda filum</i> , "sea twine".....	.1200	2.688
			<i>Chondrus crispus</i> , "Irish moss".....	Trace.	.....
			<i>Gelidium corneum</i>	Nil.	.....

Three methods of extracting iodine have been followed in Scotland, known as the kelp process, the char process, and the wet process. The following accounts of them are abridged from Stanford's report (l. c.), and from Stanford's article in Thorpe (1899):

Kelp process.—This, the primitive method, is similar to that pursued for the extraction of soda from rockweeds. It is unsatisfactory and wasteful, owing to the fact that a large part of the iodine is lost by evaporation and a large part of the remaining substances are not utilized. One hundred tons of wet seaweed usually make 5 tons of dried kelp, and, as only half of this is soluble, 2½ tons are the actual product of the labor of cutting, carrying, drying, and burning 100 tons of raw weed. The fused mass of carbon and ash resulting from the burning of the dried weeds is lixiviated with water, and the solution is evaporated to remove the chlorides, sulphates, and carbonates; the concentrated mother liquid is then treated with sulphuric acid, the resulting sulphur and sulphates are removed, and the remaining acid liquor is treated in a lead-lined retort with manganese dioxide, which, with the free sulphuric acid, liberates iodine; the iodine passes off in vapor and is condensed in a series of earthenware receivers adapted to the retorts. The chemical reaction in this case is as follows:



Char process.—This has for its object the prevention of loss of valuable material by volatilization and decomposition, and consists in heating dry seaweed in iron retorts or brick ovens. The tangle swells in the retorts and is converted into a very porous charcoal, from which the salts are readily washed. This charcoal is reported to be an efficient decolorizer and deodorizer. The superiority of the char process over the kelp process will be seen from the following comparison of the results of treating four tons by each process:

Item.	Kelp process.	Char process.	Item.	Kelp process.	Char process.
Crude product.....pounds..	1,500	3,000	Loss of salts.....pounds..	220	.....
Per cent of dried weed.....	18.7	37.5	Loss of iodine.....do....	15.98	.....
Salts recovered.....pounds..	657	877	Loss of salts per ton of tangle..do....	54	.....
Iodine produced.....do....	13.27	29.25	Loss of iodine per ton of tangle..do....	3.99	.....

Wet process.—Air-dried tangle is boiled with a solution of sodium carbonate, and the mass is filtered. The precipitate is composed largely of cellulose, while the filtrate contains, besides the salts, a peculiar gummy substance, algin. When the filtrate is treated with sulphuric acid, algin is precipitated. The solution, after the removal of algin, is neutralized with calcium carbonate, evaporated, the easily crystallized salts are removed, and the mother liquor is treated for iodine in the usual manner.

This process is the most economical, in that it increases the yield of salts and iodine and reduces the cost by the production of algin and cellulose. The comparative value of the three processes may be readily appreciated from the following table, the figures being on a basis of 100 tons of dry tangle:

Items.	Kelp process.	Char process.	Wet process.
Dry weed utilized (per cent)	18	36	70
Crude product (tons)	18	36	^a 33
Salts extracted (tons)	9	15	20
Iodine extracted (pounds)	270	600	600
Residuals (tons):			
Kelp waste (valueless)	18		
Charcoal		36	
Tar; ammonia		(x)	
Algin			20
Cellulose			15
Dextrin, etc			(x)

^a Water extract.

Writing of the Scotch iodine industry, Stanford (l. c.) noted that the “drift kelp”, the only kind now used in making iodine, consists of two species of *Laminaria*, which are always submerged and are torn up by the violent gales so common on the west coast. In Ireland the plants are sometimes cut under water with long-handled hooks. These plants are much damaged by rain or fresh water and are often, after drying, almost valueless, but if properly cured they contain ten times as much iodine as the rock weeds.

OTHER USES OF THE KELPS.

The collateral substances produced during the extraction of iodine by the wet process deserve consideration on account of their prospective value in the arts. These substances are algin, cellulose, dextrin, and mannite, in addition to the various salts elsewhere referred to. The following account of algin and its compounds is adapted from Stanford (1884), by whom this substance was discovered:

If the long fronds of the *Laminaria [digitata]* be observed after exposure to rain, a tumid appearance will be noticed, and sacs of fluid are formed from the endosmosis of the water through the membrane, dissolving a peculiar glutinous principle. If the sacs be cut, a neutral, glairy, colorless fluid escapes. It may often be seen partially evaporated on the frond as a colorless jelly. This substance, which is then insoluble in water, is the remarkable body to which has been given the name of Algin. The natural liquid itself is miscible with water, but coagulated by alcohol and by mineral acids. It contains calcium, magnesium, and sodium, in combination with a new acid, which is called alginic acid. When this natural liquid is evaporated to dryness it becomes insoluble in water, but it is very soluble in alkalies. This new substance is so abundant in the plant that on maceration for twenty-four hours in sodium carbonate in the cold, the plant is completely disintegrated. The mass

thus obtained has great viscosity, and is difficult to deal with on that account. It consists of the cellulose of the plant mixed with sodium alginate. The cells are so small that they pass through many filters, but by cautiously heating it, the mass can be filtered through a rough linen filter bag, the cellulose being left behind, and after the algin is removed, this is easily pressed.

The solution contains dextrin and other extractive matter, and it is then precipitated by hydrochloric or sulphuric acid; the alginic acid precipitates in light gray albuminous flocks, and is easily washed and pressed in an ordinary wooden screw press. It forms a compact cake, resembling new cheese, and has only to be stored in an ordinary cool drying room, where it can be kept any length of time. If desired, by adding a little bleach during the precipitation, it can be obtained perfectly white. The algin can be sent out in this state; it is only necessary to dissolve it in sodium carbonate in the cold for use. If, however, it be sent out as sodium alginate, it must be dissolved to saturation in sodium carbonate, the carbonic acid is disengaged, and sodium alginate is formed. If potassium or ammonium carbonate be used, the alginates of potassium or ammonium are formed, which are similar to the soda-salt. The bicarbonates of these alkalies may also be used; but the caustic alkalies are not such good solvents.

The sodium alginate forms a thick solution at 2 per cent; it can not be made above 5 per cent, and will not pour at that strength. Its viscosity is extraordinary. It was compared with well-boiled wheat starch, and with gum arabic in an ordinary viscometer tube; the strengths employed were as follows; it was found impossible to make the algin run at all over the strength employed:

Gum arabic solution, 25 per cent, took 75 seconds=1 in 3.

Wheat starch solution, 1.5 per cent, took 25 seconds=1 in 8.

Algin solution, 1.25 per cent, took 140 seconds=1 in 112.

So that algin has 14 times the viscosity of starch, and 37 times that of gum arabic.

The solution may be alkaline, or neutral, or acid, according to the degree of saturation; if alkaline, it may be made distinctly acid by the addition of hydrochloric acid, but any excess at once coagulates it; a 2 per cent solution becomes semisolid on this addition.

The evaporation is effected in a similar manner to that of gelatin, in thin layers on trays or slate shelves, in a drying room with a current of air, or on revolving cylinders heated internally by steam; high temperatures must be avoided. The solution keeps well. Thus obtained, the sodium alginate presents the form of thin, almost colorless, sheets, resembling gelatin, but very flexible. It has several remarkable properties which distinguish it from all other known substances.

It is distinguished from albumen, which it most resembles, by not coagulating on heating, and from gelose by not gelatinizing on cooling, by containing nitrogen and by dissolving in weak alkaline solution, and being insoluble in boiling water; from gelatin, by giving no reaction with tannin; from starch, by giving no color with iodine; from dextrin, gum arabic, tragacanth, and pectin, by its insolubility in dilute alcohol and dilute mineral acids.

It is remarkable that it precipitates the salts of the alkaline earths, with the exception of magnesium, and also most of the metals, but it gives no precipitate with mercury bichloride nor potassium silicate.

Alginic acid is insoluble in cold water, very slightly in boiling. It is insoluble in alcohol, ether, and glycerin. The proportion of soda ash used is one-tenth of the weight of the weed, and the cake of alginic acid obtained is usually about the same weight as the weed. The quantity of dry alginic acid is given below:

Algæ.	Water.	Alginic acid.	Cellulose.	Algæ.	Water.	Alginic acid.	Cellulose.
<i>Laminaria digitata</i> :				<i>Laminaria stenophylla</i> :			
Stem	37.04	21.00	28.20	Frond	40.02	24.06	15.06
Frond	44.00	17.85	11.00	<i>Laminaria bulbosa</i>	43.28	17.95	11.15
<i>Laminaria stenophylla</i> :				<i>Fucus vesiculosus</i>	40.10	12.22	12.22
Stem	34.50	25.70	11.27				

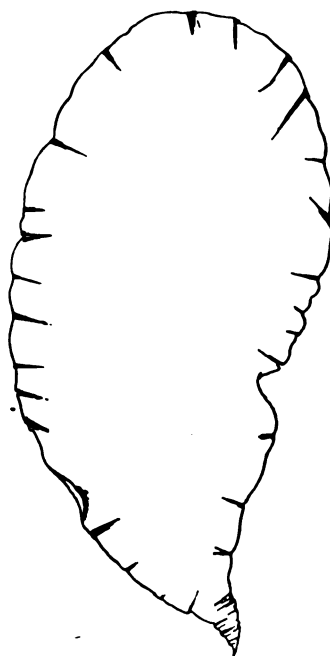
It is not necessary to extract the salts first with water; it comes to the same thing to act on the seaweed at once with soda ash, and to recover the salts by evaporation of the solution, after the alginic acid has been precipitated. In this case chloride of calcium, or of aluminum, may be employed, the

alginate of calcium or aluminum being precipitated. With either salt the alginate is thrown down instead of rising to the surface of the liquid, and the cakes are more compact and easily pressed. In addition to the cheapness with which it can be procured in almost any quantity, as a by-product in alkali works, now all thrown away, the calcium chloride has the advantage of throwing down the sulphates in the salts, and decomposing them into chlorides of potassium and sodium, which are easily separated, and do not require the tedious and expensive processes necessary in the lixiviation of kelp. The same remark applies to aluminum chloride, which can be cheaply obtained by dissolving bauxite in hydrochloric acid. Either salt can be decomposed by hydrochloric acid, and the calcium and aluminum chlorides recovered; or the salts can be decomposed by sodium carbonate. The calcium alginate, when dry, is very like bone, as the dry alginic acid is like horn. The aluminum alginate is soluble in caustic soda, forming a neutral solution, and giving, on evaporation, a substance like algin, but harder and making a stiffer finish; it is also soluble in ammonia, the salt becoming an insoluble varnish on evaporation. The alginates of copper (blue), nickel (green), cobalt (red), chromium (green), and zinc are all soluble in ammonia, and form beautiful colored insoluble films on evaporation. So also do the alginates of platinum, uranium (yellow), and cadmium. The latter is exceedingly soluble in ammonia. The alginate of chromium is also soluble in cold water, and it is deposited on boiling the solution, becoming then insoluble.

With bichrome, algin acts as gelatin, the mixture becoming insoluble under the influence of light. The silver alginate darkens very rapidly under exposure to light, and suggests applications in photography. Algin forms a singular compound with shellac, both being soluble in ammonia; it is a tough sheet, which can be rendered quite insoluble by passing it through an acid bath.

Algin and its salts appear to have a wide range of usefulness. Some of these are indicated by Stanford (l. c.). Thus, as a sizing for fabrics, algin supplies the great desiderata of a soluble gum with marked elastic and flexible properties, and of a soluble substitute for albumen which can easily be rendered insoluble and used as a mordant. As a stiffening and filling agent, algin has an advantage over starch, in that it fills the cloth better, is tougher and more elastic, is transparent when dry, and is not acted on by acids. It imparts to fabrics a thick, elastic, clothly feeling, without the stiffness caused by starch. An additional advantage, possessed by no other gum, is that algin becomes insoluble in the presence of dilute acids; and, furthermore, no other gum has anything like the viscosity of algin, hence it is the most economical for making solutions for sizing. The alginate of aluminum in caustic soda makes a stiff dressing; in the crude unbleached state it is a cheap dressing for dark goods, and in the colorless state for finer fabrics. A glossy, insoluble surface results from the use of ammoniated alginate of aluminum.

Sodium alginate has been used for fixing mordants, and is a substitute for the various salts now used in precipitating mordants previous to the dyeing of cottons and yarns. For resolving and preventing the incrustation of boilers, sodium alginate has been pronounced by experts to be one of the best preparations, precipitating the lime salts in a state in which they can readily be blown off.



Sea lettuce (*Ulva latissima*).

The charcoal formed during the manufacture of iodine by the wet process, when combined with algin, has been largely used for covering boilers, under the name of carbon cement. Three per cent of algin is sufficient to make the charcoal cohere, and a cool, light, and efficient covering is formed.

As an article of food, algin has been suggested for thickening soups and puddings, and as a substitute for gum arabic in making lozenges and jujubes. It contains about the same percentage of nitrogen as Dutch cheese, and has a faint, pleasant flavor best expressed by "marine." In pharmacy it has a place in the emulsifying of oils, as an excipient in pills, and for refining spirits.

The cellulose obtained from the *Laminariæ*, as before described, bleaches easily and under pressure becomes very hard, so that it can be easily turned and polished. A good tough paper can also be made from it.



"Badderlocks" (*Alaria esculenta*).



Dulse (*Schizymenia edulis*).

Farlow (1876) records that the rough-dried stems of *Laminaria saccharina*, *L. longicurvis*, *L. flexicaulis*, and other large species of *Laminaria*, under the name of "artificial staghorn", were used for making handles to knives, paper cutters, and other ornamental purposes; and that at one time an attempt was made to establish a manufactory of buttons out of dried *Laminaria* stems at Marblehead; but the attempt was given up, as the buttons did not bear washing.

OTHER FOOD ALGÆ.

The number of other algæ susceptible of being prepared as palatable and wholesome foods is very large. Many of the genera utilized for this purpose in Japan exist in our waters and should be given a thorough trial.

The sea lettuce, or green laver (*Ulva latissima*), which is abundant on all our coasts, is eaten in Scotland like purple laver, and is also consumed by Indian tribes of the northwest coast.

The "badderlocks," "murlins," or "henware" (*Alaria esculenta*) common on the shores of New England and California, is eaten in Scotland. *Dilsea edulis*, which occurs on the Oregon coast as well as in Europe and Japan, is a food product in Europe, being eaten like dulse, and known by that name in Great Britain.

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